AMENDMENTS TO THE SPECIFICATION

Please add the following paragraph immediately before "Field of the Invention":

This is the U.S. National Phase of International Patent Application No. PCT/BE2004/000116 filed on August 11, 2004 under the Patent Cooperation Treaty (PCT), which was published by the International Bureau in English on April 7, 2005 as WO 2005/031702 A1, which designates the U.S. and is a non-provisional application of U.S. Provisional Patent Application Nos. 60/494,375, filed August 11, 2003 and 60/564,054, filed April 21, 2004, each of which is incorporated by reference.

Please amend paragraph [0002] on page 1 as follows:

[0002] In all fields of speech processing, the basic source-filter speech model is very frequently used. It mainly assumes that the speech signal is produced by exciting a filter (corresponding to vocal tract), ~~i.e.~~ <u>e.g.,</u> by an excitation produced by the lung pressure and larynx (source signal or the glottal flow signal).

Please amend paragraph [0007] on page 3 as follows:

[0007] In two approaches closest to the methodology adopted ~~in the present invention,~~ <u>herein</u> are those of Rabiner (*'System for automatic formant analysis of voiced speech', Rabiner and Schafer, JASA, vol. 47, no. 2/2, pp. 634-648, 1970*) and Murthy and Yegnanarayana (*'Formant extraction from group delay function', Speech Communication, vol. 10, no. 3, pp. 209-221, August 1991*). Both methodologies are based on spectral processing of speech. Rabiner's approach is based on analysis of the Z-transform amplitude spectrum and Murthy's on the minimum phase group delay function derived from amplitude spectrum. In both cases one of the most important method steps is the cepstral smoothing.

Please amend paragraphs [0008] and [0009] and the headings prior to paragraphs [0008] and [0009] on pages 3 and 4 as follows:

~~**Aims of the invention**~~

Summary of Certain Inventive Aspects

[0008] ~~The present invention aims to provide~~ Aspects of the invention include a method for estimating the formant frequencies for vocal tract and glottal flow, directly from speech signals~~. The invention~~ and further ~~aims to provide~~ include a computer ~~program~~ usable medium that implements such a method.

~~**Summary of the invention**~~

[0009] ~~The present invention relates to~~ In one aspect of the invention there is a method for estimating from an input signal the resonance frequencies of a system modeled as a source and a filter, comprising ~~the steps of~~

[[-]] determining the Z-transform of the input signal,

[[-]] calculating the differential-phase spectrum of the Z-transformed input signal (without using the amplitude spectrum), whereby the Z-transform is evaluated on a circle centered around the origin of the Z-plane,

[[-]] detecting the peaks on the differential-phase spectrum,

[[-]] distributing the peaks to either the source or the filter, and

[[-]] estimating the resonance frequencies from the peaks.

Please amend paragraphs [0014], [0015] and [0016] on page 4 as follows:

[0014] In an advantageous embodiment ~~the step of~~ attributing the peaks is performed based on the sign of said peaks. Said ~~step of~~ attributing is preferably further based on the radius of said circle.

[0015] In an alternative embodiment the method for estimating the resonance frequencies further comprises ~~the step of~~ removing zeros of the input signal's Z-transform before performing ~~the step of~~ calculating the differential-phase spectrum.

[0016] In ~~a second object the invention also relates to a program, executable on a programmable device containing instructions, which, when executed, perform the method as described above.~~ another embodiment there is a computer usable medium having computer readable program code embodied therein for estimating from an input signal the resonance frequencies of a system modeled as a source and a filter, the computer readable code comprising

instructions for determining the Z-transform of said input signal, calculating the differential-phase spectrum of said Z-transformed input signal, said Z-transform thereby being evaluated on a circle centered around the origin of the Z-plane, detecting the peaks on said differential-phase spectrum, attributing said peaks to either said source or said filter, and estimating said resonance frequencies from said peaks.

Please amend paragraphs [0023], [0024] and [0025] on pages 5 and 6 as follows:

[0023] Fig. 7 represents a flowchart of the method according to ~~the invention~~ one embodiment.

Detailed description of ~~the invention~~ Certain Inventive Embodiments

[0024] ~~The invention targets~~ Certain embodiments target the estimation of resonance frequencies (formant frequencies) of the source and the vocal tract contributions directly from the speech signal itself.

[0025] As will be shown, the source-tract separation problem needs to be handled with tools, which can detect anti-causal resonances. The technique ~~according to the invention~~ is more effective than current state of the art methods, mainly because it is capable of detecting causal and ~~anti-casual~~ anti-causal resonances without utilization of a particular model of analysis, but only with spectral peak analysis. Additionally, the technique has no dependency on analysis degrees as in LP analysis systems.

Please amend paragraph [0030] on page 7 as follows:

[0030] The mixed-phase model assumes speech signals have two types of resonances: anti-causal resonances of the source (glottal flow) signal and causal resonances of the vocal tract filter. ~~The invention aims to~~ Certain embodiments estimate these resonances from the speech signal. The estimation method is based on analysis of 'differential-phase spectra'.

Please amend paragraph [0034] on page 9 as follows:

[0034] In the solution according to ~~the invention~~ certain embodiments, the problem is first redefined in a more general framework of 'differential-phase spectrum'. The differential-

phase spectrum is defined as the negative derivative of the phase spectrum calculated from the signal's z-transform, evaluated on a circle with any radius centered at the origin of the z-plane. This definition makes the group delay function a special case of differential-phase spectrum, where the radius of the circle is r=1. Changing the radius from r=1 to other values yields a new circle in a region where zeros do not exist. By calculating differential-phase spectra at this new circle, the spiky effects of the zeros can be avoided and resonance peaks can be tracked. ~~The invention~~ Certain embodiments advantageously ~~makes~~ make use of the insight that signal resonances can be tracked from differential phase spectra calculated on circles with radius different from 1 (the unit circle), ~~i.e.~~ e.g., on circles with a radius either larger or smaller than 1. The analysis of more than one differential-phase spectrum is advantageous for the estimation of source and tract characteristics due to the poles existing inside and outside the unit circle (though a single differential-phase spectrum can also reveal all causal and anti-causal resonances). Therefore the method preferably includes the step of processing more than one differential-phase spectrum calculated at circles with different radius, as this yields an improved robustness.

Please amend paragraph [0036] on page 11 as follows:

[0036] The roots (zeros) of a z-transform polynomial can be determined by a numerical method. The obtained set of roots of the z-transform polynomial can be divided into two sets of roots (which corresponds to dividing the z-transform polynomial into two polynomials). The obtained two sets of roots correspond to the spectral representation of glottal flow and vocal tract contributions of speech signal : when classifying the roots according to their distance to the origin of the z-plane (i.e., their radius), roots outside the unit circle are classified as glottal flow roots and roots inside the unit circle as vocal tract roots. For estimation of the characteristics of one of the systems, it is preferred to remove the set roots corresponding to the other system and then perform analysis. For example, for estimation of vocal tract characteristics, glottal flow roots which are out of the unit circle[[,]] are removed from the complete set of zeros and then the differential-phase spectrum calculation is performed.

Please amend paragraph [0039] on page 12 as follows:

[0039] Finally, Fig. 7 summarises ~~the method~~ a process of estimating resonance frequencies 700 according to ~~the invention~~ one embodiment in a flowchart. The various steps are as described previously. The process 700 begins with speech data 702 that is input to a windowing state 710. Proceeding to state 720, process 700 performs a z-transform and then advances to state 730 for calculation of zeros. Continuing at state 740, process 700 performs classification of zeros according to radius. If the radius (r) is less than one (that is, inside the unit circle (UC)), process 700 advances to state 750 and performs a differential-phase spectrum calculation outside the UC. Based on the results of the calculations at state 750, process 700 then performs peak picking at state 752. Returning to the description of state 740, if r is greater than one (that is, outside the UC), process 700 advances to state 754 and performs a differential-phase spectrum calculation inside the UC. Based on the results of the calculations at state 754, process 700 then performs peak picking at state 756. At the completion of peak picking states 752 or 756, process 700 continues at state 760 to perform classification of vocal tract formants and glottal flow formants according to the sign of the peak and radius of the analysis circle for the differential-phase spectrum calculation. The results of the classification performed at state 760 are vocal tract formant frequencies 762 and glottal flow formant frequencies 764.